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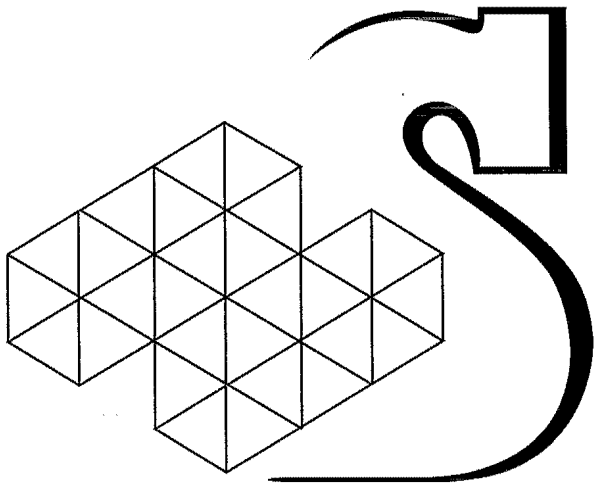

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Review and Analysis of "Human Factors Engineering Requirements for Canadian Forces Command and Control Information Systems": Guidelines and User Manual Final Report

PWGSC Contract No. W7711-6-7286/01-SRV
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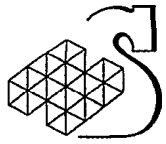

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CR 1999-032

REVIEW AND ANALYSIS OF "HUMAN FACTORS ENGINEERING REQUIREMENTS FOR CANADIAN FORCES COMMAND AND CONTROL INFORMATION SYSTEMS": GUIDELINES AND USER MANUAL

Final Report

by:

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PWGSC Contract No. W7711-6-7286/01-SRV
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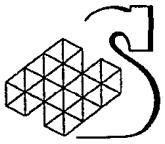


Executive Summary

The overall goal of the present contract was to provide a review and analysis of the Engel and Townsend reports "*Guidelines for Human Engineering Requirements for Canadian Forces Command and Control Information Systems*" and "*User Manual: Guidelines for Human Factors Engineering Requirements for Canadian Forces Command and Control Information Systems.*"

The following were the major objectives of the work.

- Determine the utility of the first document in assisting the development by Human*systems* Incorporated (HSI) of a draft Human Engineering Program Plan (HEPP) for the Tactical Battlefield Command System (TBCS) that was currently under development by DLR4-5.
- Provide a commentary and analysis on the general utility of the two documents for future use by the Canadian military community to provide guidelines for the integration of Human Factors Engineering (HFE) into future military acquisitions for Command and Control Information Systems (CCIS).
- Review how the presence of the reports, had they been available at the time of project initiation, might have influenced the development of a sample of military CCIS acquisition projects.
- Comment on how the reports might influence the future direction of the TBCS program.

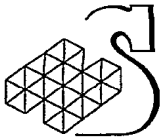
The objectives were accomplished through a combination of review and analysis of the relevant material by HSI, integrated with the results from interviews with four SMEs, chosen for their recent experiences as senior managers in DND CCIS acquisition projects.

The first objective could not be strictly accomplished since the two reports arrived at some time after the HSI draft HEPP deliverable was due. Nevertheless, a retrospective review was conducted to determine what use the document might have been had it been available to HSI. This review showed that the reports contained many of the key concepts that would have validated HSI's existing understanding and knowledge base that were used in the preparation of the HEPP. In particular, the reports were organised in a manner that made the information easy to extract and provided an overarching framework that was well integrated and logically consistent. The reports could not have provided assistance for the analysis of the risk and benefits of the major HFE activities associated with the HEPP, a task requested by the TBCS PMO.

With respect to the second objective, the overall conclusion was that the reports would be highly beneficial to the military community for providing guidance on integrating HFE into future CCIS acquisitions project. A number of suggestions are made that would enhance the scope, utility and usability of the reports. These issues were identified both by HSI and military SMEs who were interviewed in the course of the contract; they include scope, utility, usability and the relationship with other relevant documents. It should be recognised that in many cases these enhancements go beyond the scope of the original Engel and Townsend work commissioned by DCIEM

Suggestions for broadening the **scope** include.

- Widening the scope of task and mission analyses to include additional core concepts derived from NATO STANAG 3994 and other relevant documents (also to include special analyses for situation awareness and communication)
- Integrating and expanding issues relating to measures of performance and effectiveness for CCIS systems
- Expanding the section on HF analyses to incorporate unique HF issues related to teams (in particular, function allocation and team decision making).



The following recommendations are made as having potential to enhance the **Utility** of the reports.

- Provide sections that outline the "business case" for the human factors engineering effort and to show the costs and benefits of the major HFE activities.
- Clarify the relationship between the HEPP and the overall systems engineering plan. Also clearly differentiate the HF responsibilities and activities done by the PM team prior to contract award and throughout the system development process, from those performed by the contractor and the IV&V team.
- Provide more specific guidance on how the data that are output from HF analyses can be used to inform the process of requirements development, and later, the detailed system design, and the role of HFE SMEs in this process.
- Broaden the scope to include issues that may be unique to the navy and air force communities.

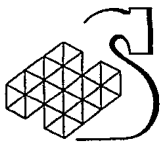
Several suggestions were made to enhance the **usability** of the reports to make the information easier to access for busy military officers. Suggestions included reducing the surface density of the text by improved formatting, wider use of graphics, hypertext links and, most importantly, widespread illustration of issues through specific military examples and case studies.

A final suggestion was to **integrate** the report with other highly relevant material contained in other DCIEM technical reports and NATO documents.

With respect to the third objective, there was good consensus among the SMEs that the availability of the reports at the start of their respective projects would have had a major beneficial effect. These benefits would have occurred in areas such as clearly defining existing system deficiencies in a disciplined manner, identifying the major HFE tasks and responsibilities, doing early mission, function and task analysis and providing the basis for ensuring that an appropriate HEPP could be put into place.

The final objective, to determine how the reports might inform the future direction of TBCS was somewhat moot, given that by the time the present review was conducted, the TBCS project had already moved forward to conduct a broad mission, function and task analysis. Therefore, instead of addressing this objective, we have taken the opportunity to raise a number of issues relevant to the actual ongoing HFE task analyses and data modelling being conducted for TBCS, which are important and are not addressed directly in the reports. These issues include: the nature and utility of the HF data to be generated by the analyses, the need to consider special analyses for situation awareness and communication issues, since these are core processes in a CCIS, integration with other CCIS systems (scope and boundary issues), doctrine and team considerations.

Our overall conclusion is that the material contained within the reports would be highly beneficial in providing a valuable reference source to the military community, to better ensure the appropriate application of HFE in the system acquisition, design and development processes. Widespread dissemination of the material covered in the reports, and its adoption by the military community, are likely to reap benefits in terms of ensuring that future systems meet operational needs, and are built in a manner than mitigates risks to operational utility, usability and overall system development and fielding costs.



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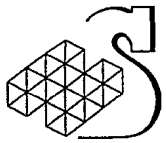


1. Scope and Background

This work was commissioned by the Defence and Civil Institute of Environmental Medicine DCIEM as part of a standing offer contract to support ongoing Defence Research and Development Branch efforts to improve the application of human factors engineering in DND CCIS projects. Contract No. W7711-6-7286/01-SRV. The Technical Authority is Major L. Bossi (DCIEM).

1.1. Objective

The objective of this work is to comment upon the utility of two related reports[1],

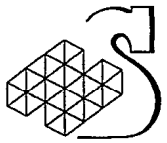
1. *Guidelines for Human Engineering Requirements for Canadian Forces Command and Control Information Systems*; and
2. *User Manual: Guidelines for Human Factors Engineering Requirements for Canadian Forces Command and Control Information Systems.*

The analysis of the reports is based upon the following perspectives

- The approach that may have been taken to TBCS development if the guidelines provided in the preceding reports had been applied from the inception of the project.
- The generic usefulness of the reports to the acquisition process for future command and control information systems (CCIS)
- The usefulness of the reports in framing the Humansystems Incorporated (HSI) report "Tactical Battlefield Command System: Human Factors tasks and risks during the procurement cycle"

An initial objective was to recommend the immediate elements of a HFPP that would be required to take the TBCS project forward from the present point. However, as events have transpired, the whole scope of the former TBCS project has been re-evaluated, and project management has already embarked upon a course of implementing some of the core components of a HEPP, as recommended in the Engel and Townsend reports.

[1] Note: The scientific authority indicated that a third related document, "*Requirements for a Human Factors Engineering Plan for Command and Control System Development*", was not be reviewed in detail, but read as relevant contextual material.



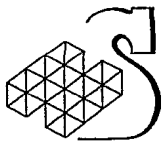
2. Method

The various sections of the Engel and Townsend reports were compared with MIL-STD-46855 and other relevant documents to identify value added components specific to CCIS HFE requirements. Relevant experience from Human*systems* Incorporated (HSI) extensive work in the area of development and evaluation of military information systems was also used as a context for evaluating detailed aspects of the report.

The utility of the draft Engel and Townsend reports for developing the HSI Report "Tactical Battlefield Command System: Human Factors tasks and risks during the procurement cycle" was evaluated.

The possible utility of the Engel and Townsend reports (had they been available from project onset) to the TBCS project development was evaluated through interviews with the TBCS Project Director (PD) and the Leader, Functions Group, Information Systems Technology Group, Defence Research Establishment Valcartier (DREV).

The generic usefulness of the reports was also explored through two further interviews with the Project Manager ARDS/ADM and the HFE Program Manager/Government Focal Point Displays and Internal Communication System R/SAOC Modernisation Program



3. Results

The results are organised as follows:

- Commentary on the usefulness of the "Guidelines" report for developing the HSI outline HEPP for TBCS (section 3.1)
- Detailed commentary on and analysis of the "Guidelines" (section 3.2)
- Commentary on the "User Manual" (section 3.3)
- Specific detailed comments on the "User Manual" (section 3.4)
- Interviews with the project managers (section 3.5)

The initial draft of the report was received by HSI in mid April, and this draft contained only part one of the report (Guidelines). The full report with appendices was not received until early June. As a consequence, and given the end of April deadline for delivery of the draft TBCS HEPP to DCIEM, the report *could not be used as a major input* to the HSI HEPP preparation.

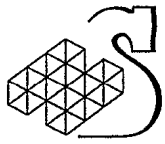
3.1. Usefulness of the "Guidelines" report

The "Guidelines" report provides a detailed listing of the major components that would be expected to form the core of an HEPP for CCIS. These are outlined using standard HEPP headings and contain a clear description of the overall processes and tasks to be conducted. An appendix provides detailed data item descriptions (DIDs) for each of the core elements of the HEPP.

These aspects of the Guidelines assisted HSI by validating HSI's understanding of the major topic headings for the HEPP. This information was organised in the "Guidelines" in a highly coherent manner, and provided important cross validation for HSI with others sources of information concerning HEPP content areas. HSI was also able to make use of some of the detailed description of several of the human factors tasks that make up the HEPP. While much of this same information was obtainable from MIL-STD-46855, the organisation of the "Guidelines" resulted in some time saving in assembling the information into a coherent process model.

Since the Guidelines report dealt only with the standard HEPP content areas this limited its utility in assisting the preparation of the HSI report, which dealt with some broader issues relating to an overall Project Human Factors Plan (PHFP). This meant that the adaptation of the Guidelines report content material only accounted for less than 20% of the required effort for producing the Humansystems report.

The overall PHFP would normally include issues such as preparation of a Statement of Requirements (SOR) and Statement of Work (SOW), Independent Verification and Validation (IV&V), training and job re-design, and post-installation activities such as review of issues relating to doctrine and standard operating procedures. This PHFP forms the master plan for co-ordinating and integrating all HF activities during the entire procurement cycle. It also spells out the assignment of general areas of HF responsibility to the various players, which include: the contractor, the PMO's own HF advisor(s) (in-house, sub-contracted, or within a Defence Research Establishment and the IV&V team. Hence, the PHFP is at a higher level than the subsequent, more detailed, HEPP prepared by the contractor to cover implementation of the HF responsibilities assigned by the PHFP.



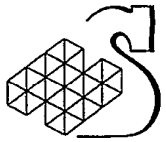
These issues are covered by Engel and Townsend in the "Requirements" Report mentioned earlier in footnote 2. Hence, to gain the necessary appreciation of these and related issues, the reader is advised to consult the Requirements report as a companion document to the User Manual and Guidelines Report.

3.2. Detailed commentary on the "Guidelines"

For the most part, the nature of this commentary is in the form of a critique that identifies areas where the Guidelines report could be strengthened. It must be acknowledged that overall this report provides sound guidelines and principles, with which HSI agrees and supports. For practical reasons we do not enumerate, or comment upon, all of the many instances of the material with which we are in agreement. Hence, the result of this approach is that, on balance; the review may appear to be more generally critical rather than laudatory. This would be an inappropriate conclusion to draw, since the intention of this review is to improve upon, and make more usable, a report which already goes much further towards meeting the needs of the military in developing a CCIS than any other documentation that is currently available, and of which HSI is aware.

The major conclusions from the analysis of the Guidelines report are as follows.

- Overall this report contains much of the information contained in MIL-STD-46855. This information is *sensibly re-organised and integrated* to provide better information flow than the original. Generic points in the original document are replaced by specific references to CCIS, where appropriate. The information provides a potential user with a succinct but detailed summary of the activities outlined in MIL-STD-46855 that are required for the implementation of an HEPP into the project acquisition cycle.
- The report *does not cross-reference other related documents* developed by DCIEM which are of relevance to the development of the HF plan (e.g. references 5, 7). These provide additional information that a PM would need to understand in applying the HF plan.
- While the report is well organised, it may not provide a structure that maps the HEPP in an obvious way to the understanding which military users may bring concerning the *overall systems engineering process*. This may be exacerbated because some potential users may have little knowledge of human factors beyond Staff College, while others may have seen human factors only applied late in system development. Few will have an immediate appreciation of the full scope of an integrated HFE effort and will need some supporting arguments to "buy in" to the proposed approach. In this respect, the provision of some elements of the separate Engel and Townsend "Requirements" report which argues the case for integrating HFE into systems development would be useful in providing this additional background familiarisation.
- A section on measures of performance and effectiveness is provided but this does not incorporate *specific measures of C2 effectiveness* that would be appropriate for CCIS.
- The suggestion is made in this section of the report that *subjective rating scales* should not be used as proxies for objective empirical measures of performance. However, this is a debatable issue given the centrality of subjective measures to the assessment of workload, which is a critical performance indicator for C2 processes. Also, subjective estimates form the basis for some of the simulation parameters that underlie modelling of tasks and network simulations of function allocation.



- A useful section on *decision support requirements* is provided, but this is not tailored specifically to CCIS needs.
- To complement the sections on design for decision support, which is a clear core element for a successful CCIS, it would have been appropriate to incorporate issues relating to *design support for situation awareness*[2] *and communication effectiveness*.
- Some improvements could be made to section (6.4.3) which deals with tailoring to meet the scope and needs of the acquisition project. This section breaks down the application of HF activities into phases of analysis, human factors in design and human factors in test and evaluation. The usefulness of this section could be augmented by providing an *overarching framework* to guide the reader on how the sequential nature of each of the critical human factors activities map onto the overall system acquisition plan. This section should be cross-referenced to the general sequential outline of the global HFE plan (GHFEP) that is found in the "Requirements" report.

Overall, the Guidelines report provides an excellent and well organised outline of the typical activities and associated documentation that would be expected to form the basis of an effective HEPP designed for use in developing and acquiring military information systems.

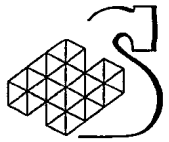
In summary, the areas where the utility of the report could be enhanced are as follows, the report should

- Provide a clearer outline of the sequential steps in implementing a HEPP as they relate to the ongoing project acquisition cycle.
- Provide information on those human factors tasks that must be considered prior to the point at which an HEPP usually comes into force.
- Address specific considerations that should be applied to an HEPP that would be developed for a CCIS application. For example, make references to CCIS specific measures of performance, unique operating environments, C2 organisational structures, issues of doctrine or standard operating procedures, and systems integration both horizontally and vertically within military command levels.
- Add sections on design for situation awareness and communication.
- Provide a risk/benefit analysis, of performing each of the HEPP major tasks in a CCIS environment[3].
- Provide better links to the mental model that PM's with varying experience will bring to the report.
- Provide improved signposts for PM's who, because of circumstances, cannot integrate the HF plan from the project outset.

It should be recognised that some of the suggestions made above may go beyond the specific mandate DCIEM provided for the preparation of the reports by Engel and Townsend, which required that the contractor was to observe and review the application of HFE in the ARDS/ADM

[2] The term situation awareness is used frequently in this report. Since military and scientific personnel reading this report may interpret this concept in different ways, a brief overview of the concept of situation awareness is provided in Annex B.

[3] This suggestion arises both from an expressed guideline provided by TBCS project management to HSI in preparation of the draft HEPP, as well as from points subsequently arising from interviews.



project and "*produce a final report and a generic HFE plan for CCIS reflecting the ARDS ADM experience*"

3.3. Commentary on the "User Manual"

Several major issues are outlined below.

3.3.1. Consideration of additional forms of HFE analysis

As in most generic HEPPs, the User Manual makes a strong case for workload analysis as a primary means of identifying both the appropriateness of the design and the optimal allocation of functions. However, workload analysis is a tool that provides little initial, *specific* feedback for system developers in terms of directly identifying the underlying causes of inappropriate workload. For example, when using modelling methods, a typical practice is to grossly manipulate allocations of functions, or modify processes or their task sequences, to determine their effects on workload. However, such an approach, which may be both costly and time consuming, may in the end fail to identify the exact factors in the system that drive inappropriate workload. In particular, it is not clear how the overall analysis of workload, or its typical breakdown into perceptual, cognitive and psychomotor components, provides insight into the detailed issues of operator-system performance that need to be understood from a design perspective.

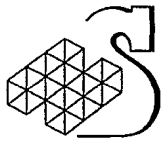
We believe that workload is a product of several intervening drivers of performance, which include factors such as situation awareness, decision making and communication effectiveness. Hence from a design analysis perspective, it makes sense to analyse how the potential design may impact upon each of these factors. The importance of these areas to overall C2IS effectiveness were substantiated in an earlier HSI report commissioned by DCIEM, (reference 5).

Hence, it is recommended that the analysis of situation awareness, decision making and communication be specified as core required components of an HEPP for all CCIS to complement workload analysis.

A further consideration in the use of workload and other HF analyses, which are based closely on existing systems and procedures, is that the analyses may have limited generality, and hence usefulness, in informing requirements specification or detailed design for "revolutionary" systems. That is, newly emerging systems may take advantage of new technologies, may need to reflect changes in doctrine and may need to accommodate potential reductions in personnel resources. Thus, drivers of workload and existing system function allocations may have no direct counterpart in next generation systems. In such cases, it would seem advisable to recommend that HF analyses concentrate on the higher order mission functions and examine the generic information, communication and decision needs for potential users of such systems.

3.3.2. Risks, benefits and local appropriateness of the various HEPP activities.

While the report contains a complete inventory of all of the elements of an HEPP, there are no guidelines provided for the inexperienced user, of the various trade-offs that may need to be made in applying an HEPP under typical system development constraints. The report contains a useful and comprehensive section on tailoring the plan for specific systems engineering and project management methods, but the report does not address difficult issues concerning the ultimate value of each of the human factors analyses. Hence, it gives the impression that all aspects of the plan need to be implemented no matter what the local context (notwithstanding the section of the report that deals



with small applications development). Sections of reference 7 could be cross-referenced or integrated into a final document, to provide the PM with a greater understanding of risks and benefits.

More generally, summary statements should be provided of the major benefits to be gained from implement each component of the HEPP and the corollory of the types of risk that will be incurred if the activity is not carried out.

3.3.3. Specificity in the measures of system effectiveness

This section would be more useful if an inventory of measures of effectiveness were provided for users of the manual who are unfamiliar with the appropriate measures, nor have the ability or background to develop them by themselves. In a CCIS environment there are a limited number of practical measures that provide key indicators of system performance. These have been documented by several sources and have been integrated and summarised in references 5 and 6.

3.3.4. Specific guidance on how to use Human Engineering data to influence statements of requirements and specific details of design.

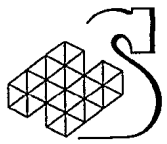
Following the various HF analyses that are conducted as part of the HEPP, a major task for the PM will be to use the resulting HF data to influence system specification and in some cases detailed design requirements. This can be a daunting task, since it will not be intuitively obvious to PM's on how to do this. HF task analyses and modelling will typically produce volumes of task inventories, operational sequence diagrams, and hundreds of graphs of modelled data. Somehow these data must be translated into information, which in turn must be applied to requirements definition. Since this process is not taught in staff college, and most PM's will have little or no experience in how to embark upon such a task, some detailed guidance should be provided on how this process is to occur. Indeed, it might be useful to provide an annex to the report that provides sample data from a limited military context, to illustrate the nature and form of the HF data that are actually generated by mission, function and task analysis. The danger exists that if the PM cannot understand the data generated, or comprehend its relevance to system design, or translate the data into a requirements statement, then the entire HF analytical process, which produce such outputs, may lose credibility in its claim for a central role in the general systems engineering analysis of a new system.

3.3.5. Consideration of the military "team" environment

One of the major differences between a typical civilian and a military information system, is the added dimension of the integral nature of team functions to achieving military C2 objectives. The traditional HEPP does not take into account the additional user requirements that may be arise when a tightly integrated team must function with a shared information system. Emerging areas such as team situation awareness and implicit communication modes will require some context specific research to be performed following the initial function analysis. In this way, issues may be identified relating to the specification of requirements that are unique for team operations. Considerations of team operations will also have a major impact on test and evaluation and design feedback.

3.3.6. Language confusions

In the experience of HSI, there are frequent miscommunications between the various parties engaged in the system development process concerning core concepts, because of local differences in interpretation of meanings. One frequent area of misunderstanding occurs over the issue of "criteria" and related terms; few people understand the clear distinction between criteria, measures,



and standards. Hence, it would be useful to have a glossary of technical terms with definitions provided for naïve (or non-technical) readers. Other confusions may occur between HF personnel, military SMEs and software developers in the usage of terms such as function and tasks, and the concept of situation awareness.

3.4. Specific detailed comments on the "User Manual"

The numbers assigned to the comments below refer to paragraph numbers in the user manual.

2.2 Some useful references are missing, such as the ANSI-HFS guidelines for workstation design and the HSI report on framework for evaluation and measures of performance and effectiveness for C2 systems.

2.0 An argument may be made against the statement that the general aim of HFE is to make systems easy for people to use. There are a number of other design goals such as improved system effectiveness, efficiency, and safety.

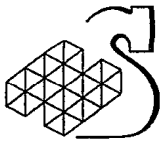
3.3.1 Table 1. The table shows that the primary assessment of design effectiveness is the measurement of speed and accuracy in doing high level cognitive tasks. However, from a design feedback or improvement perspective, such measures of overall task completion time, for example, may carry insufficient diagnosticity of design problems. Measures of "timeliness" and "completeness" may be more appropriate in some circumstances. Therefore, it will be critical to ensure that the performance measures are directed at an appropriate level of behaviour to reflect the specific information processing that the system must support. It may also be necessary to decompose some high level cognitive tasks into some of their constituent elements. An example of this would be to use separate assessments of the ability of a design to support all three levels of situation awareness; namely (i) rapid detection of new information, (ii) integration and comprehension of information into a coherent, internal representation and (iii) projection of the representation into the future, to anticipate further information needs and decisions (see Annex B. for an overview of the concept of situation awareness).

3.3.2 Four of the major differences between the application environments of a CCIS and MIS, that should be emphasised here are:

- the need for the user of a CCIS to maintain high levels of situation awareness
- the centrality of an effective communication system to achieve mission goals
- the generally high level of background message traffic that competes for attention
- the general tendency for users of the CCIS to be operating in a multi-tasking environment.

3.0 Not much detail is provided on the forms of HF *analysis*. Mission, task and function analyses tend to be *descriptive* rather than analytical in terms of their output. Workload estimates are the only true analytical method proposed here. Hence, there is a need to show the requirement for supplemental analyses of situation awareness, decision making and communication requirements.

4.1.3 The implementation of other complementary procedures to basic task analysis should be considered. These may provide additional sensitivity and validity, and could provide the level of diagnostic accuracy that will be required for design specification. Some consideration should be given to expanding the traditional view of task analysis, as



outlined in the report, to incorporating some of the ideas outlined in NATO STANAG 3994. (In particular, the references to analysis for situation awareness, information requirements and communication).

4.2.1 The military reader will not find a strong case here for the value-added component for HFE, since the identification of requirements the HF part of the analysis is not made explicit.

Perhaps a better approach would be to suggest an integrated team with army SMEs, developers and HF specialists. More stress should be given in the report to the particular importance of HF specialists in providing HFE expertise in analytical methods, their unique knowledge of available and relevant the human performance data, and their crucial role in helping translate data from HF analyses into requirements and design guidance.

It is not made clear how user performance requirements can be determined from the methodology described here. In particular, how would this approach assist in determining performance requirements for next generation systems? The role of experienced HFE personnel in assisting the translation from HFE analyses to requirements should be noted here. This may be particularly important for systems that represent a "revolutionary" design potential as opposed to an "evolutionary " approach.

One approach would be to use the data obtained from MOEs to assist in setting performance requirements, however the report does not provide any detailed MOEs for critical areas of which influence the performance of a CCIS.

The time required for developing capabilities and deficiency descriptions is probably too short and unrealistic, based upon HSI's experience across a number of project domains.

4.2.2 The section on function allocation only deals with the traditional area of human-machine allocation and ignores the question of function allocation across members of the typical military team in conjunction with the system.

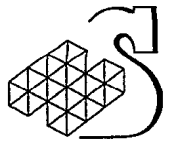
4.2.6 Consistent with the above general major comments, it is recommended that the list of HFE questions in the design review process for a CCIS be expanded as follows.

User situation awareness: will the interface and system design allow the user to rapidly detect changes in information, integrate such information into the current (battlefield) picture and project how the picture may change in the foreseeable future? Will the interface and system design allow the user to integrate map and communication based data from local and more global contexts into the relevant picture of the battlefield?

User decision making: does the system design provide the user with the necessary information at the appropriate time and formatted in a meaningful manner to facilitate both slow paced planning, or faster paced tactical, decision making?

User communication: does the system design allow users to communicate effectively and accurately with a minimum of effort? Does the system provide a means for a meaningful integration of information from different communication sources and modes? Does the system allow the user to manage communication effectively with a high volume of message traffic?

4.2.6.5 Specific measures of effectiveness should be provided here. This is certainly feasible since there is a core set of generic functions and processes that determine the overall effectiveness of most CCIS (reference #5).



4.3.3.1 Preceding comment also applies to the specification of test measures.

4.3.3.3 Examples of valid/invalid and reliable/unreliable measures could be provided here for a person unfamiliar with these concepts.

4.3.4 Note in Table 2 that an advanced form of storyboard could be a screen-based example of a piece of system functionality, produced through rapid prototyping.

4.3.6 Some additional advice should be provided on how to achieve levels of reliability in testing when the typical constraints found in a military environment (e.g. availability of test subjects) compromise the requirements for statistical significance.

4.4.1 One issue that should be mentioned here, and which may be typically relevant for most new installations of a CCIS, concerns the integration of the new system with existing, standalone systems, with which users must continue to interact to achieve mission goals. Specific examples could be provided in the task analysis and function analysis sections (4.1.2, 4.1.3) to show how these analyses take into account the future interaction between the proposed CCIS and existing systems.

3.5. Interviews with the TBCS project personnel.

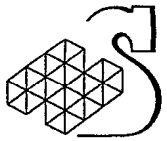
Interviews were conducted with four individuals, each of which had a unique and different perspective based upon experiences in the management of new CCIS. The individuals were:

1. Leader, Functions Group, Information Systems Technology Group DREV
2. TBCS Project Director. Written comments were also received from the TBCS Staff Officer.
3. Project Manager ARDS/ADM.
4. HFE Program Manager/Government Focal Point Displays and Program Manager for HFE for the Internal Communication System R/SAOC Modernisation Program.

The format of the interview was semi-structured with the major questions provided in advance to the interviewees. The major issues raised in each of the interviews are outlined below and grouped into themes. To reduce any overhead in translating the transcripts into a more flowing narrative, the comments are provided in "note" format. A more detailed transcription of each entire interview is presented in Annex A.

The major themes chosen for analysis were:

- Report style and organisation
- HFE Process and method
- How the information contained in the reports might have influenced the TBCS/Chameleon approach (or relevant system for the interviewee in question)
- How the reports provide insight into the major steps for the next phases of the project
- Comments on specific aspects of the reports where improvements can be made.



3.5.1. Interview with the Leader, Functions Group, Information Systems Technology Group DREV.

Report style and organisation

There is value in having the reports organised into a Guidelines Document and User Manual. Many military users will probably just opt for the brevity of the Guidelines. However, for a military user, unfamiliar with, and possibly less convinced of the need for, an HFE plan, there is a need to provide an introductory section in the Guidelines report. This section should outline the background rationale for human factors being a critical aspect of the general systems engineering program and effort. This introduction and rationale would also be needed in the case of a contractor who was unfamiliar with the full scope of an HFE effort.

The level of technical writing is appropriate for military PM's and defence scientists.

The reports are organised in a meaningful and coherent manner.

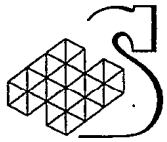
The surface style of the reports is too "dense" and does not show good design principles. In particular there are long sections of unbroken text which may be difficult to digest for the average PM who is hard pressed for time. The greater use of text and graphic formatting would help to alleviate the impression of density and make it easier for the reader to stay with complex issues.

A major concern was expressed over the small number of specific military examples. Where they were used, for example in the section on deficiencies in requirements statements, they made the concepts much more comprehensible. The use of a specific example throughout the document is recommended to assist the reader in understanding more difficult concepts such as function allocation and operational sequence analysis. Thus, a concept such as the generation of an Op Order could be viewed from the perspective of mission analysis, task and function analysis etc. Further it was suggested that more examples should be provided to illustrate DIDS.

HFE Process and method

A major concern was expressed over the fact that the User Manual did not clearly show in detail how the HFE program was integrated with other systems engineering activities. The impression was given that the User Manual seems to be strongly pushing the insertion of a new "block" into normal systems engineering process approach. This may be perceived as threatening to systems engineers and PM's. The User Manual is seen as pushing the "independent HFE model" too hard. The opinion was given that HFE is best integrated during the development of functional requirements. Whereas the User Manual appears to imply that HFE analysis is done beforehand, instead of in parallel with other technical analysis. Further, the User Manual does not make it clear how HFE is integrated into life cycle systems development. (HSI comment: *however, the bottom paragraph of page 39 clearly shows how the HFE control loop can be successfully integrated into both iterative and parallel approaches during the design phase of system development*).

There was strong disagreement with the general direction of the HFE process model proposed in many areas. The User Manual should provide more details on iterative approaches as opposed to what is perceived as the waterfall approach that is being promoted. For emerging technologies the proposed model is inappropriate, since it does not allow for some preliminary iterations through actual design implementations. There was disagreement with the approach that you can first do task analysis, then validate and then design. As a consequence, the view was expressed that the User Manual should show more clearly how HFE activities interact with ongoing prototype development. Further, you cannot write HFE deficiencies without knowing what technologies are



feasible. Essentially, a hybrid approach was advocated that combines prototyping with more formal HFE methods- quote "analyse a bit, design and develop a bit, test a bit".

How the information contained in the reports might have influenced the TBCS/Chameleon approach.

The initial approach taken to TBCS development was based upon an LFCS process model, which uses the staff planning process as a core baseline concept (taught at Staff College). This was developed into Chameleon to provide a demonstration vehicle for user-oriented concepts and functions. The lack of task analysis was discovered later in the process, as was the need to develop scenarios based upon mission analysis. Later the team came to the view that task analysis needs to be a part of iterative prototyping.

The major effect the reports would have had on the actual approach taken was in the area of preliminary mission and task analysis. This could have mitigated some cost, schedule and operational applicability risks in terms of better understanding the needs of the combat team members in the context of representative mission scenarios. Notwithstanding this, the fundamental approach may not have changed very much, since there is still a need to demonstrate a prototype and then validate this through a scenario, prior to more substantive HFE analysis activities, such as function allocation and OSD's. However, a prior mission analysis would allow priorities for the first prototype to be more easily identified.

How the reports provide insight into the major steps for the next phases of the project.

The most important process to follow next is to conduct an appropriate mission and task analysis. This should be followed with a review and analysis of function allocation, and then a comparison should be made of the product of this analysis with the functionality of Chameleon prototypes to date. The reports underline the need to ensure that the next implementation of the Chameleon prototype development incorporates a broader spectrum of HFE considerations, in particular the need for formal testing. The reports suggest that a next obvious step would be to generate a special set of HFE requirements as **part** of a functional SOR. There will also be a need to integrate HFE into predefinition activities, for storyboarding concepts, technology demonstrations, or other simulation-based acquisition approaches.

Comments on *specific aspects of the reports where improvements can be made.*

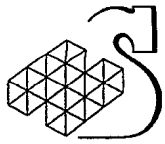
The reports do not spell out the precise make up of HFE team and individual responsibilities.

The User Manual needs to show how the HFE activities are better fused throughout the design/development cycle. It implies separate but connected processes–but a more integrated approach should be spelled out in full detail.

The User Manual provides some idea of the scope of the HFE effort, but not in enough detail. Providing an approximate estimate of the cost of each activity would not be particularly useful.

The time required for developing requirements from analysis is likely to be much more extensive than is reflected in the User Manual.

The risks associated with not doing each component of the HFE are not provided, except the User Manual does make clear the risks associated with not performing better initial analysis and requirements definition early in project development. It would be useful to provide more tangible examples of HFE work and to show how risk is mitigated.



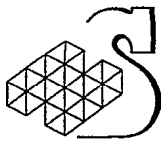
Insufficient detail is provided of the type of data that is generated by some of the HF activities, e.g. operational sequence analysis and function allocation and modelling.

No guidelines are provided on how the output of HFE analyses can be specifically used for the creation of requirements statements, particularly with respect to critical system performance areas.

4.2.2 Function allocation: the question was raised as to whether this systematic approach is practicable in army CCIS environment? An analysis of function allocation was not performed in the development of the Chameleon product, but the reports provided a good perspective on how this issue might have been approached in a more systematic manner. However, analysis should go hand in hand with developing the technology available, and is complex to implement (more information should be provided on technology constraints and enablers). This section is too remote from technology development and needs to be better integrated.

4.2.3 Was surprised to learn that there was "no fixed procedure for translating HFE data into design requirements". Some examples of types of approaches should be provided here.

4.2.6.4 Would like to see more detailed description of the actual simulation process and the level of effort required. Believes that while this may be useful for the technological component it is not clear how to model and integrate the user component.



3.5.2. Summary of Interview with the TBCS Project Director.

Summary of major points arising from interview with the TBCS PD and written comments provided by the TBCS PMO Staff Officer.

Background

There was only sufficient time available to study the Guidelines Document in detail and to quickly skim the User Manual.

The TBCS Project Director pointed out what he considered to be an important distinction between two military information systems. The larger, the Command and Control Information System, comprises the entire operating environment of the army and incorporates information needs at all levels, as well as issues relating to training, doctrine and operating procedures. The primary purpose of the CCIS is to support the commander (HSI note: it is not clear whether this refers to the commander specifically, or the command *team*). Below the CCIS are smaller sub-systems, which comprise the C2IS. These sub-systems are largely concerned with hardware and software to meet the information needs at, for example, the brigade, combat team or individual soldier levels. At the level of the CCIS, system analysis will identify several types of deficiencies. Some will require a hardware solution, others a procedure solution or changes to command structure and/or doctrine.

In general, the reports support analysis only at the C2IS level and do not deal with human factors contributions at the CCIS level, and should be expanded to incorporate this wider domain.

Report style and organisation

Overall, the information in the reports is densely packed. The average "hard pressed" PM would be unlikely to take the time to try to find the needed piece of information under typical time pressure. The format should be revised to make the search for relevant information easy to achieve (hypertext links were suggested). The further point was made that in this day of widespread electronic documentation, military personnel would rarely set aside a few hours to read through paper documentation.

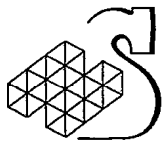
The two reports need better cross-links.

The reports are organised in a manner that the average PM would readily comprehend and the level of technical language was appropriate. However, for a reader with no background in HF, both the PD and Staff Officer believe that some prior background training would be necessary (he suggested a CD-ROM based course). The Staff Officer noted that a novice PM would have some difficulty in following the overall process.

HFE Process and method

The process and method were outlined very clearly, as were the links between the HEPP and the overall systems engineering plan. The reports outline in sufficient detail the major HF tasks, their scope and the overall responsibilities for conducting the component elements of the HEPP. However, much more detail should be provided on scope and costs to help trade-off issues. It was noted that some of this information was available through the tables and annexes in the HSI report (reference #7).

The breakdown by phase of development was useful, as were the detailed examples of the DIDs.



How the information contained in the reports might have influenced the TBCS/Chameleon approach

The information in the reports reinforces and supports the view that the PD brought to this project. At that time, the existing system development plan was already to far along to make radical changes. In general, the ongoing approach was disjointed. Had the PD been able to influence the direction of the project at the outset, he would have relied extensively on the reports, which contains essential and valuable information on how the human factors and systems planning should properly evolve, and how the HF effort should form the early core of system development.

Initial tasks in the system development would have concentrated upon mission analysis and scenario development, instead of developing functionality.

How the reports provide insight into the major steps for the next phases of the project.

Essentially, the most important information in the reports is the direction they provide concerning the immediate way to proceed for developing requirements statements for the next generation system. Specifically, the mission, function and task analyses will drive the process in the short term.

Additional items that should be in the reports that you expected to find.

Risk analysis and cost/benefits should be provided for the major HF tasks in order to allow the PM to make the necessary trade-offs.

More detailed information should be provided on the relationship between the HF analyses and system requirements specification.

3.5.3. Summary of interview with Project Manager ARDS/ADM

Background

The PM described himself as being originally an end-user artillery officer who was promoted into procurement and project management, and has been involved with C2 issues since 1988.

He was previously familiar with the MANPRINT program and saw some problems with the initial plan for ARDS/ADM development.

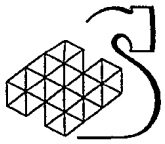
Report style and organisation

The writing flowed well. It was easy to understand because it follows the operational planning process closely; therefore an army person would relate to it. The reports were written at an appropriate level of technical language that military users would understand.

HFE Process and method

The process and method were adequately described.

The major difficulty is in the lack of explanation as to how the HEPP fits in with the overall systems engineering planning approach. This relationship should be made explicit with a schematic model. The reports read as if the HF plan drives the systems engineering process, instead of being integrated with it (particularly in areas such as mission and function analysis).



The reports tell you **what** to do but are not clear on **when** to do it or **how** to integrate with other processes.

The requirements development process needs to be better tied to the systems engineering plan.

Newer approaches to project management and systems engineering, such as quality function deployment (QFD), will provide as yet unsolved challenges on how to integrate HFE and how to identify and evaluate the HF component in a proposal that uses a QFD approach.

How the information contained in the reports might have influenced the ARDS/ADM approach.

If the reports had been available at the start of the project, it would have been of considerable benefit for planning and prioritising the initial major HF tasks to be done.

The reports make a sound case for the early identification of deficiencies and provide an excellent account of the process to be followed for such identification.

The section dealing with capability deficiencies would have been useful to formalise a method.

The reports would make it easier to assign priorities and make early decisions. The proposed approach forces you to look at entire requirement.

The proposed approach allows the clients to do their homework and define the operational concept early. The mission/function analysis leads naturally to understanding the required operational architecture.

The reports lay out a formal process. This makes for generic consistent statements and the process of arriving at them is accountable and transparent.

The User Manual clearly identifies the role of client and level of effort required in order to properly define requirements.

Additional items that should be in the reports that you expected to find.

The reports do not provide appropriate information on where to make HF trade-offs.

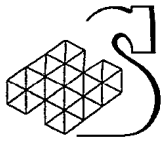
The business case for conducting a full HF program needs to be spelled out. A cost/benefit analysis would be useful. More information concerning the actual estimates of time and cost should be provided together with the expected benefits/risks.

More detail should be provided on the scope and costs of the major HF activities and also their timeline and logistics.

The general systems requirements for function allocation are not dealt with adequately. The focus of energies cannot just be on either the human or the hardware side. Also, there should be a section that deals with function allocation among personnel.

There should be a section on how IV&V fits in with the overall process.

The reports should provide more guidance on how to move from the HF analysis to the statement of requirements.



3.5.4. Summary of interview with Program Manager/Government Focal Point Displays and for HFE for the Internal Communication System R/SAOC Modernisation Program

Background

The PM had no previous specific knowledge concerning HFE, just that acquired as part of an aerospace systems course. He had gathered expertise as the project evolved from DCIEM, who provided mostly verbal guidance. He was familiar with the HSI report on MOPs and Framework for Evaluation.

Report style and organisation

The reports are not as "user friendly" as they could be and read like a textbook. The content can be quite verbose, contains repeated material and places too many demands on memory across the various sections.

The User Manual was really liked, but there was less enthusiasm for the Guidelines report, and the sections on Requirements were found to be quite challenging, even with a background in the material.

The reports make demands on the reader to remember too much material across the two reports. There is a need for a better introduction and lead-in to many sections

Unless it was an officer's job to read them, the reports would be discarded and put down quickly. This is because the information is not presented and organised in a manner that makes it user friendly.

More military examples should be provided in the User Manual both for comprehension and making the business case.

HFE Process and method

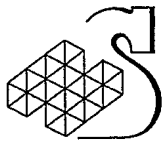
The relationship between the HF plan and other approaches to the systems engineering process needs to be explained. The proposed approach does not fit the R/SAOC IPT (integrated program teams) model well, this is a core part of IPPD process that has been adopted by US Department of Defence. The Canadian Air Force is moving towards adopting this approach and the R/SAOC program was used as a model.

The reports are weak in describing the role of IV&V.

The reports do not show clearly the chain of command in the HF team in project management hierarchy. There is a need to spell out reporting relationships and to encourage the HF plan management to be high in the program management hierarchy.

The reports are very strong on the pre-contractual work that needs to be done.

The reports should emphasise the importance of creating a database to track the HF plan (e.g. usability trial comments, IPT notes, who said what and what was done). The adoption of a usability tracking matrix was suggested in order to maintain a log of when each issue is to be addressed (which build and evaluation trial in an iterative process), the priority of each issue and the outcome.



How the information contained in the report might have influenced the R/SAOC program development

The reports are very useful and it would have been highly desirable to have had these available at the start of the project. It would have guided much of the early processes and would have spelled out clearly the need for the contractor delivering, and committing to, a viable HEPP.

The sections on developing statements of deficiencies are potentially very useful and would have resulted in a much clearer statement of deficiencies (note: he has never been on a project that starts with deficiency requirements). Other sections that would have influenced the evolution of the project are the statements on the HEPP deliverables and making the case for the HF effort.

The reports would have helped to justify the HFE budget and plan budget better.

The reports would have been of benefit to the project office in planning and integration the HF effort throughout the design, development, fielding cycle by providing clear guideline on the process.

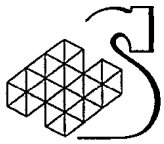
Additional items that should be in the reports that you expected to find.

The section on budget is useful but should be enhanced with some detailed budget examples drawn from previous projects in order to enhance the authority of the document. These examples should deal with making the business case for HF and provide an indication of the cost payback for the investment.

There is a need to develop a generic "briefing package" that could be used to make the case for the HF program.

There should be a section on the risks/benefits of the various HF tasks.

There should be a section outlining the need for early identification of the software required for HF test and evaluation, since the specific design for this software will have to be integrated into the overall systems software program. (Note: a similar case can be made for the development of system maintenance software).



4. Recommendations for issues to be considered by the TBCS project office

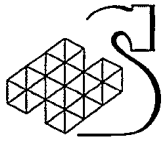
Any detailed discussion of specific steps to be taken by the TBCS project office, as guided by the Engel and Townsend reports is moot, given that the TBCS project office has made the decision to conduct a mission, task and function analysis as the next step in system development. In general, we believe that based upon the overall HEPP report and our experience with the TBCS project to date, the mission and task analysis is an appropriate step to be accomplished before moving forward in the system design and development process. Notwithstanding the scope of the HEPP outlined in the Guidelines report and TBCS SOW, we make some recommendations in this section for maximising the benefit to be gained from the ongoing analysis. Attention to the issues outlined below may mean a more extended analysis will need to be performed in some specific areas. As such, these recommendations go beyond the existing HEPP Guidelines report and existing TBCS SOW for the next phase of the project.

4.1. Nature of the human factors data to be generated

It is important at the outset of the next stage of work that the form and nature of the data obtained from the mission, function and task analysis are clearly understood with respect to the ability of the data to support subsequent requirements definition and design guidance. That is, the raw descriptive data that can be a typical product of such an analysis may be insufficient to inform this process. Interviewee #4, made a strong point of this in the context of the difficulty that systems developers had in understanding the workload analysis data. Thus, one of the primary goals in going into the analysis will be to arrive at an understanding of what forms of data will be useful for driving subsequent requirements specification and design decisions, and what further analyses of the descriptive data or tasks may be required to generate such data.

A further decision to be made in advance will be to define what constitutes critical information in the analyses and how this can be recognised and extracted from the large amount of data generated. For example, criteria will need to be established to determine how the workload metrics generated by the analysis can be interpreted in system design terms. Traditionally, workload metrics have been used for comparative assessments of different system states. However, for efficient design guidance, HFE specialists will need to provide recommendations to system designers on what values of workload are salient when they review specific areas of system functionality in order to reduce potential overload. These numbers should be precise enough to identify those critical C2IS processes that will demand particular attention in terms of design support and requirements specification. The alternate approach of running multiple simulations, while manipulating system parameters to achieve the required reduction in the modelled workload values, is probably not cost effective at this early stage of system analysis. Further, without specific HFE analysis to guide the necessary revisions to the modelled system, arriving at an optimum or satisfactory solution may be a hit or miss process. It will also be necessary to specify in advance approximate workload metric values for effective system performance, in order to know when a satisfactory modelled solution is appropriate and acceptable.

One further issue concerning the HF data generated is the extent to which the future system designs are expected to be evolutionary or revolutionary. In the case of the former, one would expect a high degree of utility in applying HFE analyses based existing C2IS systems and processes.



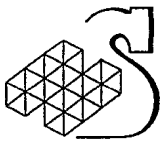
However, if future systems are expected to involve a major rethinking in the way C2IS processes could be implemented more effectively with newly emerging technologies, then the transfer and applicability HFE data derived from *task analysis* of existing systems has the potential to be uninformative to those responsible for shaping systems requirements, and, ultimately, system designers. Instead, what will be of value is a high level function analysis of the overall mission objectives and processes that will need to be performed, no matter what the ultimate shape of the final technology.

4.2. Analysis of situation awareness requirements

It remains to be seen whether the forms of analysis proposed by the TBCS PMO in the SOW for the next step in TBCS development can address the detailed requirements specification and decisions that will need to be made concerning system design to support situation awareness. The latter has been established as one of the key factors underlying effective C2 performance and confirmed in the preliminary cognitive analysis of combat team functions performed by HSI. Interviewee #4 identified the importance and usefulness of conducting such an analysis (as a supplement to workload analysis) in providing a basis for detailed design decisions. Whatever the form of the analysis ultimately adopted, the ensuing data should inform the PMO very precisely about those mission functions that depend critically on good situation awareness. In particular, these mission functions will need to be analysed from the perspective of the information requirements to support all three levels of situation awareness (reference 11). While the SOW addresses the need to identify the information requirements in order to perform tasks, and the need to define the cognitive components of the task, the SOW fails to specify how these two elements interact to shape, for example, the specific user's information needs. Defining the information required to conduct a task and the cognitive process involved, in itself tells nothing about the way to optimise the system design to enhance information processing. Analysis of situation awareness requirements would be one area that would benefit from the more detailed analysis of this complex interaction.

4.3. Analysis of communication requirements

Communication effectiveness has been identified as being a core requirement for the successful achievement many C2 mission goals, tasks and sub-tasks. The HFE approach to dealing with communication issues outlined in the reports, and the TBCS SOW, deals with communication flow primarily through analyses based upon operational sequence diagrams. For such analyses to be useful from a system specification and design perspective they will need to go beyond identifying message sources, destinations, flow, traffic peaks, overlaps and lags. The analyses will need to take into account the cognitive requirements for the transmitted information in terms of many factors relating to how the transmitted information influences situation awareness and decision making. Message data in themselves only become meaningful to the recipient in the context of these two factors. Issue such as message salience, immediacy, timeliness, reliability, uncertainty must all be considered in the context of understanding message information. In order to meet the needs for specifying system design, these issues will need to be addressed by extending the analysis to yield relevant data that go beyond the typical descriptive flow diagrams produced in operational sequence analysis. Further consideration also needs to be given to the management of communications in the high volume environment that is typical of many military applications.



4.4. Integration with other systems, scope and boundary issues

Clearly the analysis for TBCS C2IS needs must take into account the broader command and communication infrastructure and other military engineering systems within which TBCS will operate. The flow of information down from LFIS through TBCS to IPCE will require not only an HFE analysis within the combat team, but also at the critical points of interface with other C2 systems. There are no specific, detailed HEPP guidelines as to how this analysis is to be conducted and some initial planning will be required to understand just what can and cannot be achieved with the standard HEPP HFE analyses proposed.

A further factor to be considered will be the potential conflict between system wide information formatting demands and local requirements. On the one hand, there will be design constraints to ensure consistency of data formats between LFIS/TBCS and TBCS/IPCE to avoid confusions among users who may operate at the boundary points in order to perform mission tasks (or whose training is predominately with one system or the other). On the other hand, the need for these constraints will need to be balanced against the appropriateness of the system design when optimised for local TBCS requirements.

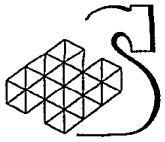
Similarly, it is likely that within the combat vehicle, the TBCS will interface with weapons and potentially vehicle mechanical and operational systems. Hence there will be a need for detailed analyses to understand the user's information requirements and information flow across and between systems.

4.5. Doctrinal constraints

In considering the scope and goals of the function analysis, early decisions will need to be made concerning the degree to which a "green fields" approach will be taken, that is, there are no prior constraints to thinking about possible function allocations. This would mean that existing doctrinal issues concerning the operational missions performed by combat teams and the individual roles performed by team members will not be relevant factors in optimising the allocation of functions. However, this is unlikely to be a realistic approach and hence there are likely to be many constraints involving these factors. This will certainly reduce the scope of the function analyses if there are early decisions to respect existing doctrinal constraints. If this is the case, much of the functional allocation issues will be centred on human/system trade-offs.

4.6. Over-analysis

One of the dangers in a major mission, function and task analysis is the danger to over-analyse the obvious or simple. Informed HFE analysis involves not only the use of computer based analytical techniques, but also expert analyses by experienced HF specialists together with the appropriate army SMEs. The issue here is often one of cost effectiveness in terms of finding the fastest and most efficient way to answer a design or requirements definition issue. For example, given the well documented high error rates associated with the transcription process of plotting map-based information from text or audio sources (whether in a planning phase, or under actual battle conditions), the ability to automatically send graphic overlays, traces or symbols with correctly plotted data to update the users current map, would be of considerable benefit. While it is true that all of the individual tasks and actions which underlie this processes of passing spatial information could be readily modelled, it is not clear that having a "precise" number to reflect the saving in time or errors would enhance the design decision reached.



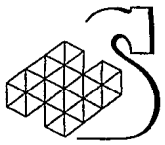
There remains a danger to the credibility of the profession if we can provide only expensive, lengthy and minutely crafted answers to questions that can be addressed with relative ease and efficiency by less involved processes.

Some guidelines on the selection of appropriate HFE analysis for systems of varying complexity can be found in recommendations provided by NATO DRG Panel-8 RSG.14 (reference 9).

4.7. Team requirements

Issues relating to the effective performance of teams have emerged only recently in the HFE literature. Consequently, many of the traditional analytical methodologies have yet to incorporate sections into a HEPP to deal with team performance issues. While it is beyond the scope of the present report to provide details on how to incorporate analysis for team performance into a HEPP, this issue is "flagged" as one that will require early attention as TBCS moves into the next phase of the system analysis.

It is possible that all of the team issues can be accommodated within the planned analyses, however early cognisance of issues which go beyond the individual performance of team members may need to be addressed. Some of these include team situation awareness, "shadowing" by some team members of the functions performed by others, implicit knowledge that exists only at the team level and team decision making. Observations of "team behaviours" during simulations and exercises suggest that factors such as "body language", voice intonation, gestures and facial expressions all carry important cues for communicating aspects of common intent. To date, traditional approaches to task analyses have not tended to capture such information.



5. Recommendations for next steps for developing the HEPP reports.

In this section we make some suggestions on how DCIEM might go beyond the existing material provided by Engel and Townsend in order to provide military users with a comprehensive reference package that would provide assistance in the integration of HFE into the systems development process. These suggestions are based partly on our own ideas, augmented and reinforced by comments and suggestions arising from the interviews.

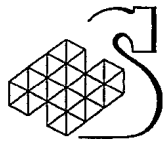
The Engel and Townsend reports provide the majority of the core content that is required for a comprehensive HEPP for CCIS development and this will create a sound foundation for any future work. The suggestions provided below for expanding and improving the potential utility and usability of the document and may be categorised into four main areas: (i) expanding the core content, (ii) enhancing utility, (iii) enhancing usability and (iv) integration with other relevant material. Within the limitations of the scope of the present work and budget, these issues will be described in point form only.

5.1. Expand the core content

- Broaden the scope of task and mission analyses to include additional core concepts derived from NATO STANAG 3994 and other relevant documents.
- Integrate and expand issues relating to measures of performance and effectiveness for CCIS systems.
- Tailor the section on decision support requirements to the specific context of a CCIS.
- Expand the section on HF analyses to incorporate the other core processes that support effect C2IS, (situation awareness, communication effectiveness and decision making, in addition to workload) and include unique HF issues related to team functions.
- Provide additional information on the important role to be played by HFE specialists in translating data from HFE analyses into design requirements and recommendations.

5.2. Enhance utility

- Provide a section that outlines the "business case" for the HFE effort; consider the provision of a "briefing package" that PMs could use to support arguments to superiors about the need for a strong HFE program.
- Provide a section that shows the costs and benefits of the major HFE activities. In particular, document the risks associated with not performing specific analyses.
- Show how the HEPP integrates with the overall systems engineering plan. In particular, consider the specific challenges associated with locating the HFE effort in emerging systems engineering processes.
- Clearly differentiate the HF responsibilities and activities done by the PM team prior to contract award and throughout the system development process, from those performed by the contractor and the IV&V team.



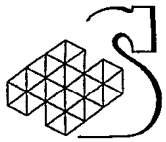
- Provide more specific guidance on how the data that are output from HF analyses can be used to inform initially the process of requirements development, and later, the detailed system design.
- Broaden the scope to include issues that may be unique to the Navy and Air Force communities.

5.3. Enhance usability

- At present the surface structure (i.e. the interface) of the reports is not conducive to rapid acquisition or comprehension of the information, particularly for the brief time slices that busy military personnel seem able to allocate to reading such material. There are large sections of unbroken, single font, single pitch text, and reviewers commented that the document read like a textbook. This surface structure could be improved by the adoption of an overall document style that makes fewer demands on the reader. A number of HF and document design guides are available to provide appropriate style recommendations. More graphics and tables should also be provided to amplify and illustrate main points.
- Provide a means by which users can quickly locate topics of interest.
- Consider developing a hypertext document to provide improved navigation within and between the reports and links between related topics.
- Wherever possible provide strong, illustrative, military examples to facilitate comprehension of major HF analyses, methods and data. One possibility would be to produce a CD-ROM or video with example case studies that depict difficult decisions and problems facing the PM, and appropriate steps to be taken.
- Several military officers have suggested that paper as a medium is going out of favour at DND and that the primary means of information transmission is electronic. This results in a reduced willingness to spend time with paper as a medium and to read lengthy paper-based documents. Therefore, some consideration should be given to producing an electronic document for military use. This should go beyond the simple conversion of paper into diskette, but should take advantage of the additional learning benefits that accrue with well-designed, multimedia information packages. Thus, many of the above recommendations could be accommodated in a highly effective manner through the production of an interactive CD. This would supplement the existing core material with a more effective interface, improved means of rapid access to critical information, improved linkage between related issues, improved graphics, specific examples to illustrate points etc.

5.4. Integrate with other relevant documents

- DCIEM has itself produced many reports on applying HFE to system design and it has also commissioned contractors to provide HFE analyses of military systems. Much of this information is highly relevant to the present context and has the potential to fill some of the present gaps in coverage. Therefore, means should be found of supplementing the core content of the present reports with references to relevant material in these other documents.
- Provide references to other related non-DCIEM material, e.g. NATO STANAG, recent US technical reports.



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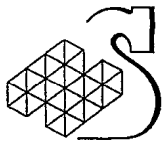


Annex A: Interview Data

A.1 Point form transcription of interview with the Leader, Functions Group, Information Systems Technology Group DREV at DREV, July 6 1998.

Background knowledge

Have you had an opportunity to read and/or study any similar or related documents previously – if so – what were they?

Has read some DND technical reports on some on requirements capturing but nothing on HFE. Has some familiarity with HCI guidelines (e.g. Engel and Townsend report).

Report organisation and style

Was the report organised in manner that made sense?

Yes – in particular liked summaries. It is dense-more examples –a PM will not take time to go through. Need some up front buy in. Need more examples. Also need to make surface structure user friendly. Use consistent example throughout e.g. planning.

Was the report organised in manner that enabled you to understand the various HEPP components and how they related to one another?

Yes-very clear.

Was the report written in the appropriate level of technical language?

The writing was dense and concentrated, but not too technical. Liked descriptions of mock-up, prototyping environment.

Do you think that the typical military officer would have difficulty in understanding the technical aspects of the report?

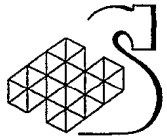
Users probably will have difficulty in reading all of the technical aspects of the report unless the reader can be convinced initially of the importance of HFE to the overall systems engineering effort. The user needs clear up front motivation to keep going through the detailed technical sections.

There needs to be a greater number of examples to illustrate the text, particularly for task and function analysis. There is no guidance as to exactly what to do with the outcome of the analyses. There is not enough information to allow a PM to recognise a good task analysis from a bad one.

The examples provided for formulating statements of deficiencies were found to be very useful.

The detailed sections on tailoring the HFE plan (5.3.2.2 and subsequent) are hard to follow because of technical density, and again examples would help in comprehension.

More examples should be provided to illustrate DIDS.



Was it useful to divide the report into separate guidelines and implementation sections?

Yes. However, if users read only the "guidelines" then they will need a better introductory summary on what makes a good HFE.

May also need to provide greater rationale and incentive to convince a contractor to implement the full HFE plan (if only the "Guidelines" document were to be given to them).

Generally believed that army users would find the first part of the user manual (not detailed description of DIDS) more useful, supplemented by the summary in the "Guidelines" section.

Report contents and concepts

Were there any new concepts in the report which you had not encountered previously?

Generally not familiar with full scope of HFE, in particular what was involved in task and function analysis (only familiar with HCI issues).

Need more examples –since it was not easy to understand all concepts.

Suggestion is to follow one example throughout, e.g. the flow of an Op Order. This could then be decomposed using task analysis and OSDs, storyboard of design prototypes.

It was not clear how OSDs relate to regular data and process models. Will HFE methods allow everything to be represented in the data model? Seriously questions whether this can this be done for emerging technologies without a physical or some form of prototyping mock-up. Sees the use of mock-ups to assist task decomposition.

The section on Hartson and Hix should be expanded. (Note: this approach was strongly endorsed).

Would like to see a greater emphasis on iterative development as opposed to the evolutionary/waterfall methods proposed.

Does not buy into the differences outlined in the report in the requirements approach to the development of CCIS versus hardware. While a distinction may exist now, does not believe that this is the way it should be, since there should be a human should be focus for both types of system in the future. This is where simulation based acquisition methods are particularly useful for hardware acquisition.

Advocates a hybrid approach that combines prototyping with more formal HFE methods.

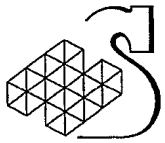
Were there any concepts with which you were previously familiar, but became clearer to you as a result of reading the reports?

Yes for task analysis and HFE scope in general. Scope and cost information was new; believes that the reports underestimate the true cost of HFE in iterative development.

The reports are not clear or detailed enough on how to integrate HFE with other systems engineering activities. The reports seem to be strongly pushing the insertion of a new "block" into normal systems engineering process approach. This may be perceived as threatening to systems engineers and PM's. The reports are seen as being pushed the "independent HFE model" too hard.

Believes that HFE is best integrated during the development of functional requirements. Whereas the reports seem to imply HFE analysis is done beforehand, instead of in parallel with other technical analysis. Further, it is not obvious how HFE is integrated into life cycle systems development.

Believes that you cannot write HFE deficiencies without knowing what technologies are feasible.



Agrees that 5-10% estimate of total project cost for the HFE effort is reasonable, but taking into account all of the required documentation, believes that overall it would account for more than 10%. "Chameleon provides the living documentation."

Would like to have seen how HFE activities interact with ongoing prototype development; does not believe that you can first do task analysis, then validate and then design.

Were there concepts you would have expected to find in the reports but were missing?

A greater description of the Hartson and Hix approach (because this is seen as a viable approach.)

More detailed questions

Which aspects of the reports would have been useful at the very outset of the TBCS project?

The lessons learned from the TBCS field trial provided a context for understanding how some of the aspects of the reports actually can be applied, in particular, the need for early mission and task analysis.

Would you have done anything differently at the outset of the project had the reports been available?

Yes. Instead of going to the design of concept prototypes would have done more initial analysis. They would have adopted iterative approach of "analyse a bit, design and develop a bit, test a bit".

Would the reports have changed the approach adopted by DREV and TBCS, namely, moving quickly forward with rapid-prototyping and producing Chameleon?

No – still need to demonstrate prototype and validate through a scenario prior to more substantive HFE analysis activities such as function allocation and OSD's. However, a prior mission analysis would allow priorities for the first prototype to be more easily identified.

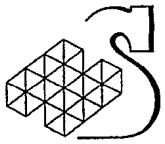
Given the current stage of development of the TBCS project, do the reports provide insight into incorporating HF aspects into system design in the next phases of the project?

Yes, first step back and do an appropriate mission analysis and task analysis. Follow this with a review of function allocation and compare the product with Chameleon prototypes to date.

The test scenario demonstration at Pettawawa was very useful for identifying Chameleon deficiencies. This demonstrates that if HFE had been there from the start it would have been integrated into development cycle and the current step back would be necessary.

Does it provide guidance on what are the next most important HF considerations? How does it do that?

Yes – will need to ensure that the next implementation reflects all HFE considerations, in particular the need for formal testing. The reports suggest that a next obvious step would be to generate a special set of HFE requirements as **part** of functional SOR. There will also be a need to integrate HFE into predefinition activities, for storyboarding concepts, technology demos, or simulation based acquisition.



Do the reports provide insight into the various HF responsibilities throughout the project acquisition cycle?

No –reports imply just roles for contractor, PM and users, what about SMEs? The reports do not spell out the precise make up of HFE team and individual responsibilities.

Would the reports assist the project office in planning and integration the HF effort throughout the design, development, fielding cycle?

The reports need to show how the HFE activities are better fused throughout the design/development cycle. It implies separate but connected processes–but would like to see a more integrated approach. E.g. in ARDS/ADM the analysis was useful but inadequately incorporated into the design of a new automated system.

Do the reports provide you with sufficient information to understand the benefits of each of the major HF activities? Yes.

Do the reports provide you with sufficient information to understand the scope and costs of each of the major HF activities?

The reports provide some idea of scope, but not in enough detail. Does not believe that costs reflect the full scope of the underlying activities. Providing the cost of each activity would not be particularly useful.

Do the reports provide you with sufficient information to understand the logistical aspects and timeline for implementing each of the major HF activities?

These are generally well described, but not convinced of the suggested sequential timeline, e.g. the time required for developing requirements from analysis is likely to be much more extensive than is reflected in the reports.

The risks associated with not doing selected aspects of the HFE are not easily comprehended except for ensuring better initial analysis and requirements definition early in project development. It would be useful to provide more tangible examples of HFE work and to show how risk is mitigated.

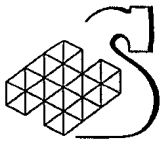
Do the reports have sufficient detail for you to understand each of the major HF activities? Yes.

Would you like to have seen more concrete military/army examples in some areas?

Yes, would like to see one example followed throughout for mission analysis, function and task analysis.

How would you see the reports assisting you in the requirements specification process as part of SOR?

Need specifically worded statements to incorporate HFE paragraphs? Descriptions of human factors engineering, mission, function and task analysis would be useful in specifying requirements.



Are there remaining areas of uncertainty concerning the implementation of a HF program plan that are not addressed by the reports?

Fusing HFE with iterative development.

Can you provide a brief historical review of the way you considered implementing HF into the initial project development scheme?

Based on an LFCS process model, the staff planning process was a core concept used as baseline (taught at Staff College). This was developed into Chameleon to provide a demonstration vehicle for user-oriented concepts and functions. The lack of task analysis was discovered later in the process, as was the need to develop scenarios based upon mission analysis. Later came to the view that task analysis needs to be a part of iterative prototyping.

Was there any useful documentation available to have helped your decision making in this process?

Auto Combat Information System (ACIS) Systems Requirement Analysis (SRA).

Would the availability of the present reports have shaped your thinking differently?

Yes, sections three and four make a good argument for the HFE case. This can be combined with the lessons learned from LFCS where they obtained data inefficiently and in a non-integrated manner by going from function to function.

A.2 Point form transcription of the interview with the TBCS PD at DND HQ July 24 1998.

Initial general comments

Overall, the document is dense and information is hard to find under time pressure. Both documents need to be linked. The average military officer would not have time to go through. People rarely take time to take a few hours to read through paper documentation.

Terminology: what is a system? The physical hardware/software plus the process/people/ this is a CCIS; the CCIS is only there to support the commander. The sub-component is the C2IS, which comprises the physical components of the system used by many different personnel. Requirements for CCIS are at a higher level, only some of which will involve the C2IS. Deficiencies will show that some require hardware solutions, procedure solutions, changes to command structure, doctrine. It is all information management.

Reports focus more on C2IS, whereas he would like to be able have a report that addresses the larger CCIS issues.

Questions and responses

Have you had an opportunity to read all of the sections of the reports?

Has just read **the Guidelines Document.**

Have you had an opportunity to read and/or study any similar documents previously – if so – what were they?

On ARDS project read some of the Engel and Townsend reports, previously back in 1992.

Were the reports organised in manner that made sense to you?

Yes. But there was too much to weed through in the time available in a typical DLR office; –need faster access to information.

Were the reports organised in manner that enabled you to understand the various HEPP components and how they related to one another?

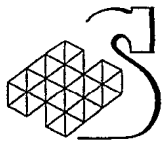
Yes – but 4.3/4.6 should go together. The organisation should be comprehensible for a naïve reader.

Were the reports written in the appropriate level of technical language? Yes.

Do you think that the typical military officer would have difficulty in understanding the technical aspects of the reports? If so, which?

Yes. But those with no experience in HF and concepts would need a special course or learning module on CD-ROM.

Was it useful to divide the reports into separate guidelines and manual sections? Yes



On the whole which do you think army users would fine more useful?

Would need both; the requirements for detail and the manual for cross reference.

Were there any new concepts in the reports that you had not encountered previously? If so, what were they?

Yes, the training requirements for simulations (these are often overlooked).

Were there any concepts with which you were previously familiar, but became clearer to you as a result of reading the reports?

The table on development phases and requirements was useful.

Also the section on MOP's and MOE's provides useful generic information. He does not need more detail here because the actual measures depend too much on local context.

Another important section was that on testing for validation- through prototypes and mock-ups.

Were there concepts you would have expected to find in the reports but were missing?

Yes, the big system (CCIS) view is missing.

Detailed

Which aspects of the reports would have been useful at the very outset of the TBCS project?

How HF fits into general systems engineering. Also of use is the breakdown of HF activities by phase.

DID's would have been useful.

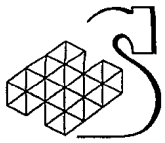
Would you have done anything different at the outset of the project had the reports been available? Would the reports have changed your approach to moving quickly to the rapid-prototyping approach adopted by TBCS and DREV?

Because of his own background (a "systems approach type") and his post-graduate education and experience with ARDS, the PD came to the project believing that HF analysis must drive system development. But the project was in place already and committed to Chameleon development. He tried to steer the project in the direction of having HF become the core initial activity, since the ongoing prototyping was being done out of context of the HF analysis. The reports reinforce the need to take a system wide view. TBCS should focus on requirements development at battlefield level and below and then whether LFCS can meet that functionality. HF methodology should be used to drive the process.

Do the reports provide guidance on what are the next most important HF considerations? How do thry do that?

Yes, would provide good overall guidance for future work.

Do the reports provide insight into the various HF responsibilities throughout the project acquisition cycle? Yes.



If not, in which of the following areas do you think you would use it the most: pre-contract, requirements definition, post contract-system development, implementation and fielding?

The reports stress the need for a strong front-end process, but HF must run throughout the entire development cycle.

Would the reports assist the project office in planning and integration the HF effort throughout the design, development, fielding cycle? How – strengths and weaknesses?

Yes. However, the reports would be considerably better if the information was easier to access.

The reports clearly show how the project fits into the overall system engineering cycle.

Do the reports provide you with sufficient information to understand the benefits of each of the major HF activities? – Yes in the "User Manual".

Do the reports provide you with sufficient information to understand the scope and costs of each of the major HF activities?

Would like to see much more on scope and costs to help trade-off issues.

Do the reports provide you with sufficient information to understand the logistical aspects and timeline for implementing each of the major HF activities?

Yes, for the most part (in the "User Manual").

Do the reports have sufficient detail for you to understand each of the major HF activities? Yes.

Would you like to have seen more concrete military/army examples in some areas?

Yes, need many more of these for the "User Manual".

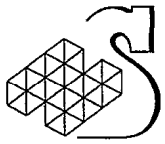
How would you see the reports assisting you in the requirements specification process?

Essentially, the most important information provided by the reports concerns the immediate way to proceed for developing requirements statements for the next generation system.

Are there remaining areas of uncertainty concerning the implementation of a HF program plan that are not addressed by the report? No.

Can you do a brief historical review of the way you considered implementing HF into the initial project development scheme? How did that change as the project evolved?

The prior approach was disjointed with no coherent process. Demonstration prototypes of system functionality drove the development approach. As the project evolved a new integrated approach developed with HF as core.

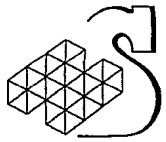


Was there any useful documentation available to have helped your decision making in this process?

Not really – nothing that was easily accessible or made available to requirements officers.

Would the availability of the present reports have shaped your thinking differently?

Very definitely, although it really only reinforced own beliefs as to what would be the appropriate approach for system development.



A.3 Comments provided in writing by the TBCS PMO Staff Officer in response to outline questions submitted in advance by HSI.

GENERAL

Have you had an opportunity to read and/or study any similar documents previously - if so - what were they?

Yes, I have read plenty of documents and here are 3 I have available at work :

a. ACCES Assessment of Command and Control During a Division-Level CPX, Late Spring 1991.
b. Cognitive Analysis, Design and Evaluation Framework
c. Task Analysis for Conduct Intelligence Planning

Were the reports organised in manner that made sense to you?

I had some difficulty but overall it was easy enough to understand.

Were the reports organised in manner that enabled you to understand the various HEPP components and how they related to one another?

I had trouble understanding section 5 of User Manual: Guidelines for Human Factors Engineering Requirements and why they explained it the way they did. Although the document had some impact analysis of inadequate statement of deficiencies for example, it did not address the risk taken by a Project PD if the decision was made not to do a certain part of the HFE plan. Risk analysis in general, was poorly done.

Were the reports written in the appropriate level of technical language?

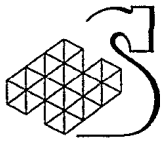
Yes, the documents were written to an appropriate level but you must remember I have attended many meetings and tried to apply the process over the last 3 years. Someone coming in for the first time would find it slightly difficult to follow in my opinion.

Do you think that the typical military officer in charge of an C2IS acquisition project would have difficulty in understanding the technical aspects of the reports? If so, which?

Yes, I think he would and the HFE plan is a good example of this. I also feel a new officer would find it difficult understanding the overall process. Once a basic understanding is achieved of the subject matter the document starts to become more important. I believe an officer in charge of such projects should receive some basic courses on HFE such as the ones available through the "learning tree" program.

Was it useful to divide the reports into separate guidelines and implementation documents?

Yes, I like the divisions.



Were there any new concepts in the reports that you had not encountered previously? If so, what were they?

Yes, the document makes several comparisons with civilian management information systems. This helps in understanding and putting the military environment in proper context. These sections in the document helped me understand the importance of a contractor who understands and has built military systems.

Were there any concepts with which you were previously familiar, but became clearer to you as a result of reading the reports?

The contents of CCIS HFE requirements documents, in particular DIDs (pg 106).

Were there concepts you would have expected to find in the reports but were missing?

Yes, I was hoping to see and get a better understanding of Risk Analysis.

DETAILED

Which aspects of the reports would have been useful at the very outset of the TBCS project?

The document provides a good outline and that is what is most important for starting a project. The document provides a plan without which you have nothing.

How would they have been useful?

An important part of any project is understanding the deficiencies of a system and how one goes about to determine these deficiencies.

Would you have done anything different at the outset of the project had the reports been available?

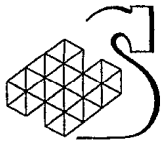
I would have looked at the development of mission scenarios or a composite scenario to examine the requirements.

Would the reports have changed your approach to moving quickly to the rapid-prototyping approach adopted by TBCS and DREV?

I was never in favour of the rapid prototyping approach so these reports would not have changed my mind.

Given the current stage of development of the TBCS project, do the reports provide insight into incorporating HF aspects into system design should the project move ahead in the foreseeable future?

Yes, without question HF aspects would need to be incorporated into the design regardless of the stage of development.



Does it provide guidance on what are the next most important HF considerations? How does it do that?

Yes, it does by giving the desk officer a process to follow regardless in what stage of development the project maybe in.

Do the reports provide insight into the various HF responsibilities throughout the project acquisition cycle?

To some degree.

If not, in which of the following areas do you think you would use it the most: pre-contract, requirements definition, post contract-system development, implementation and fielding?

I feel these reports are helpful throughout the complete life cycle of a project. They will for a new project, in the pre-contract and requirements definition phase provide a guidance and awareness into HFE that an officer did not have previously. I believe in this phase these reports will be of most value.

Would the reports assist the project office in planning and integration the HF effort throughout the design, development, fielding cycle? How - strengths and weaknesses?

The strengths are in the overall HFE process and the reports that need to be produced in the forms of DIDs. The weakness is on risk analysis as mentioned in my earlier comments.

Do the reports provide you with sufficient information to understand the benefits of each of the major HF activities?

Yes to some extent; this is an area that could be expanded.

Do the reports provide you with sufficient information to understand the scope and costs of each of the major HF activities?

No not in any significant detail unless you consider 5% of the overall project budget. The report does bring out one important detail and that is the

Do the reports provide you with sufficient information to understand the logistical aspects and timeline for implementing each of the major HF activities?

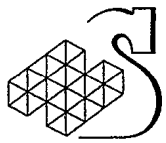
No it does not but I would imagine this would be extremely difficult to produce.

Do the reports have sufficient detail for you to understand each of the major HF activities?

I do not have sufficient experience and since I have never developed requirements using this process it is difficult for me to comment on the major HF activities.

Would you like to have seen more concrete military/army examples in some areas?

I think examples are an ideal way of enforcing the process. The few examples that are present in the reports are good as it assisted me in understanding what was happening. Overall most definitely the reports could use more examples.



How would you see the reports assisting you in the requirements specification process?

I am not sure what you mean here? Are you asking system or software requirements? The reports give me a guideline to follow as I mentioned in my earlier comments for system requirements. I still have some doubts on how a system engineer will deal with these developed requirements to actually build a system.

Are there remaining areas of uncertainty concerning the implementation of a HF program plan that are not addressed by the reports?

No, none that I haven't already mentioned.

What are they? What improvements could be made?

Risk analysis and examples are the two areas I would like to see improved.

Can you do a brief historical review of the way you considered implementing HF into the initial project development scheme?

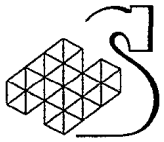
N/A

How did that change as the project evolved?

N/A

Would the availability of the present reports have shaped your thinking differently?

Yes, the availability of these reports would have changed my initial plans. I also had a draft version of these reports and I used them make many of my decisions.



A.4 Note form transcription of interview with the Project Manager ARDS/ADM at DND HQ December 11 1998.

Initial general comments

The PM described himself as being an end-user (artillery officer) employed as deputy project manager during the development phase and has no engineering or computer science background. He assumed his present position as the project was being wound down. He has been involved with C2 issues since 1988.

He was previously familiar with the MANPRINT program.

The hardest part of any project is trying to figure out what problem it is you are trying to solve. HF will certainly facilitate this but it most not be seen as a end but strictly as a means to an end.

Major comments

If the reports had been available at the start of the project, it would have been of considerable benefit for planning and prioritising the initial major HF tasks to be done.

The business case for conducting a full HF program needs to be spelled out. A cost/benefit analysis would be useful. More information concerning the actual estimates of time and cost should be provided together with the expected benefits/risks.

The major weakness with the reports is that it fails to show how to integrate the various HF activities with a general systems engineering planning approach. It reads as if the HF plan **drives** the systems engineering process, instead of being integrated with it (particularly in areas such as mission and function analysis).

The reports only present one approach to addressing the HFE issues in respect to CCIS. They may very well be other equally valid approaches/methods to look at complex system such as Quality Function Deployment.

The reports make a sound case for the early identification of deficiencies and provide an excellent account of the process to be followed for such identification.

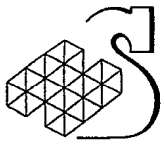
Questions and responses

Have you had an opportunity to read all of the sections of the reports? YES

Received a copy earlier in year and used it as the basis for a SOW for CMC – centred on developing statements of deficiency.

Believed there was a strong need to document existing deficiencies.

Arrived at this decision independently, but the validation provided by the reports for this approach provided a good start.



Have you had an opportunity to read and/or study any similar documents previously – if so – what were they?
Attended lectures on MANPRINT while on Tech Staff Course in Shrivenham.

Has read general systems engineering books.

Participated in HF workshop sponsored by PMO ARDS ADM and held at MacDonald Detwiler and also received a copy of the proceedings.

Were the reports organised in manner that made sense to you?

Yes – it flowed well. It was easy to understand because it follows the operational planning process closely; therefore an army person would relate to it.

Were the reports organised in manner that enabled you to understand the various HEPP components and how they related to one another?

Yes. Although found some difficulty with section 5.4.1 – launching HFE plan.

The major weakness with the organisation is to see how to integrate the various sections with a general systems engineering planning approach.

This relationship should be made explicit with a schematic model.

The reports tell you **what** to do but are not clear on **when** to do it or **how** to integrate with other processes.

Not immediately evident on where to make HF trade-offs.

The requirements development process needs to be better tied to the systems engineering plan.

Were the reports written in the appropriate level of technical language?

YES –pitched at the right level.

Do you think that the typical military officer would have difficulty in understanding the technical aspects of the reports? If so, which? NO

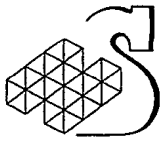
Was it useful to divide the reports into separate guidelines and implementation sections?

Yes. These would have different uses depending on the phase of the program

On the whole which do you think army users would find more useful?

Both must be read since they are tied together.

Were there any new concepts in the reports which you had not encountered previously? NO



Were there any concepts with which you were previously familiar, but became clearer to you as a result of reading the reports?

No, because of previous good exposure.

There was a reverse problem (concepts made less clear in the reports): The section on function allocation is not clear, especially 4.4.2.3. The relationship to Fitt's list could be explained. Page 28 contains too much technobabble.

Would like to have seen some information on function allocation among personnel.

Would have liked some cross-reference to other ways of looking at problem, especially quality function deployment (QFD). This approach could result in a different way of doing HF. QFD starts with a functional breakdown- but focuses more quickly on fundamental needs of the users. Tries to pin down one problem that is critical very early. This approach needs to be adapted from hardware design to C2. There may be a problem in trying to map HFE approach to QFD.

For PMs it may be hard to evaluate HF content in a contract proposal which uses a QFD approach.

Good for concept development but hard to see how can generically fit in with systems engineering plans.

Were there concepts you would have expected to find in the reports but were missing NO.

Detailed Questions

Which aspects of the reports would have been useful at the very outset of the ARDS/ADM project?

The section dealing with capability deficiencies would have been useful to formalise a methodology.

The reports would make it easier to assign priorities and make early decisions. Also forces you to look at the entire requirement for all aspects of the system design (HSI note: presumably by considering HFE requirements along with the standard systems engineering requirements).

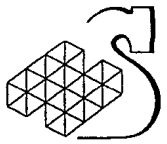
Allows client to do homework and define the operational concept early. The mission/function analysis leads naturally to understanding the required operational architecture-who does what to whom, when and how.

The reports lay out a formal process. This makes for generic consistent statements and the process of arriving at them is accountable and transparent.

The reports clearly identify the role of client and level of effort required in order to properly define requirements.

Do the reports provide guidance on what are the most important HF considerations? How do they do that?

Yes it will be easier now to know what to look for, and how to develop the systems engineering plan to integrate HF. Spells out need for HFE downstream . (As an aside, it was noted that the HF/systems engineering team needs to be cohesive and to demonstrate clear expertise.) More than just an aside, the Team (system/HF engineers) most not only be experienced in their respective fields but must also demonstrated working experience together!



Do the reports provide insight into the various HF responsibilities throughout the project acquisition cycle?

Yes – but would have liked to have seen this done within the context of system engineering plan. As written, the reports make it look as if HF sits on top of everything as opposed to being integrated.

Would the reports assist the project office in planning and integration the HF effort throughout the design, development, fielding cycle? How – strengths and weaknesses?

Problems of integration as described above. For example tasks listed in section 3.2 a,b,c, are all found in systems engineering plans. Therefore, how does the approach recommended differ from good systems engineering?

Do the reports provide you with sufficient information to understand the benefits of each of the major HF activities?

No, would like to see a section on the business case analysis.

Do the reports provide you with sufficient information to understand the scope and costs of each of the major HF activities?

No, would like to see more detail

Do the reports provide you with sufficient information to understand the logistical aspects and timeline for implementing each of the major HF activities?

No, these are important areas that are not covered adequately.

Do the reports have sufficient detail for you to understand each of the major HF activities?

YES. But would like more information on how IV&V fits in.

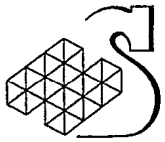
Would you like to have seen more concrete military/army examples in some areas?

Not in own case, but this would possibly be more useful for a requirements officer.

Need checklist for what is a good requirement. A few good examples would go a long way.

How would you see the reports assisting you in the requirements specification process?

The reports do not give much guidance in moving from the HF analysis to the statement of requirements.



General systems requirements for function allocation are not dealt with adequately. Cannot just focus energies on either the human or the hardware side.

Are there remaining areas of uncertainty concerning the implementation of a HF program plan that are not addressed by the reports?

Less obvious is how to integrate into systems development cycle.

Can you do a brief historical review of the way you considered implementing HF into the initial project development scheme?

HF issues were only mentioned briefly initially. But a new PM brought a strong HF perspective – but it occurred too late.

Part of the problem was developing R&D expertise within Canada; this was a more complex process than just buying a piece of hardware.

Whole effort must exist within a program reality – especially if there is no clear mission.

A.5 Note form transcription of interview with the HFE Program Manager/Government Focal Point Displays and Program Manager for HFE for the Internal Communication System R/SAOC Modernisation Program, December 11 1998.

General Comments

This is a useful document and it would have been highly desirable to have had something similar in place at the start of the project. It would have guided much of the early processes and would have spelled out clearly the need for the contractor delivering, and committing to, a viable HEPP.

The sections on developing statements of deficiencies are potentially very useful, as are the statements on the HEPP deliverables.

The section on budget is useful but should be enhanced with some detailed budget examples drawn from previous projects in order to enhance the authority of the document. These examples should deal with making the business case for HF and provide an indication of the cost payback for the investment.

There is a need to develop a generic "briefing package" that could be used to make the case for the HF program.

There should be a section on the risks/benefits of the various HF tasks.

There should be a section outlining the need for early identification of the software required for HF test and evaluation, since the specific design for this software will have to be integrated into the overall systems software program. (Note: a similar case can be made for the development of system maintenance software).

The relationship between the HF plan and other approaches to the systems engineering process needs to be explained.

The reports are not as "user friendly" as it could be. It can be quite verbose, contains repeated material and places too many demands on memory across the various sections.

Specific Questions

Have you had an opportunity to read all of the sections of the reports?

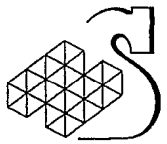
Read all, but skimmed over some details in the various DIDs.

Have you had an opportunity to read and/or study any similar documents previously – if so – what were they?

NO – no previous specific knowledge, just that acquired as part of an aerospace systems course.

Gathered expertise along the way from DCIEM, who provided mostly verbal guidance.

Used some material from the HSI report on MOPs and framework for evaluation.



Were the reports organised in manner that made sense to you?

Really liked the User Manual, but was less enthusiastic about the Guidelines report. Found this too verbose and there was too much redundancy for things that are said elsewhere.

The reports make demands on the reader to remember too much material across different sections of the two reports.

Were the reports organised in manner that enabled you to understand the various HEPP components and how they related to one another? YES

Were the reports written in the appropriate level of technical language?

Found the section on Requirements quite challenging, even with a background in the material.
Need better introduction and lead in to many sections
The document reads like a textbook.

Do you think that the typical military officer would have difficulty in understanding the technical aspects of the reports? If so, which?

Unless it was the officer's job to read them, the reports would be discarded and put down quickly. This is because the information is not presented and organised in a manner that makes it user friendly.

Not enough examples were provided in the User Manual.

Was it useful to divide the reports into separate guidelines and a user manual?

YES: each took a slightly different perspective.

On the whole which do you think air force users would find more useful?

User Manual for general purposes; the Guidelines document would be more useful for contract managers.

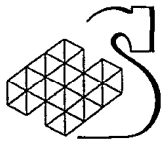
Overall found the User Manual much more useful.

Were there any new concepts in the reports that you had not encountered previously?

Yes – budget information was useful. Would like to see concrete examples to support the authority of document.

If so, what were they?

The section on evaluation of contractor HFE plan was good.



Were there any concepts with which you were previously familiar, but became clearer to you as a result of reading the reports?

YES-evaluation of the contractor. Developing and putting together the HEPP – really liked part about requirements deficiencies.

The section on HEPP deliverables was also good.

Were there concepts you would have expected to find in the reports but were missing?

A short executive summary of major points (found at end of user manual) would be useful to use to promote "buy-in" by others to plan.

The case for HFE needs to be made clearly.

Material from the reports could be added to the program manager's course provided by the department.

Were there any concepts with which you were previously familiar, but became less clear to you as a result of reading the reports?

YES-the Guidelines document was not clear on different test approaches (storyboard, etc). This was hard to map on to own experience with such methods.

Detailed

Which aspects of the reports would have been useful at the very outset of the project?

Making the case for the HF effort.

Ensuring that the HEPP is a contractor deliverable.

Would have resulted in a much clearer statement of deficiencies (note: has never been on a project that starts with deficiency requirements.

Would strongly buy into this process.

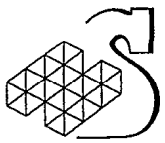
How would they have been useful?

Helps to provide detailed deficiencies in a disciplined manner.

Would you have done anything different at the outset of the project had the reports been available?

The major areas impacted would be identification of deficiencies and budget. The reports would have helped to justify budget and plan budget better.

Would have ensured deliverable of HEPP from contractor.



Does it provide guidance on what are the next most important HF considerations? How does it do that?

NO: not immediately obvious – need to dig below surface to get this.

Do the reports provide insight into the various HF responsibilities throughout the project acquisition cycle?

Yes –but does not fit the R/SAOC IPT (integrated program teams) model well, this is a core part of IPPD process that has been adopted by US Department of Defence. The Canadian Air Force is moving towards adopting this approach and the R/SAOC program was used as a model.

The reports are weak on the role of IV&V.

The reports also do not show clearly the chain of command in the HF team in project management hierarchy. There is a need to spell out reporting relationships and to encourage the HF plan management to be high in the program management hierarchy.

The reports are very strong on the pre-contractual work that needs to be done.

Would the reports assist the project office in planning and integration the HF effort throughout the design, development, fielding cycle? How – strengths and weaknesses?

YES – it is a big step forward and provides clear guidelines.

Do the reports provide you with sufficient information to understand the benefits of each of the major HF activities?

NO . It would have been useful to have a section on this. However, in reality it is more probable that a local expert would make the necessary decisions, because trade-offs have to be done on a continuing basis. Probably could not devise a manual to deal with all of the complexities that change over time.

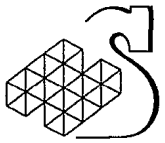
More could be done to bring our risks of not doing the particular task.

Do the reports provide you with sufficient information to understand the scope and costs of each of the major HF activities?

Yes in terms of scope, but no in terms of cost issues. Would like information on what should be the relative weighting of expenditures. Also more detail needed on level of effort.

Do the reports provide you with sufficient information to understand the logistical aspects and timeline for implementing each of the major HF activities?

Need more examples of an overall business plan.



Do the reports have sufficient detail for you to understand each of the major HF activities?

YES, but need to highlight earlier in the User Manual the need to get HF expertise (this gets left to end). Need to show then the relationship between the project office HF effort and those of the contractor and IV&V team.

Would you like to have seen more concrete military examples in some areas?

YES – this is a major need – both for comprehension and making the business case.

The reports should emphasise the importance of creating a database to track the HF plan (e.g. usability trial comments, IPT notes, who said what and what was done). Suggested the adoption of a usability tracking matrix to maintain a log of when each issue is to be addressed (which build and evaluation trial in an iterative process), the priority of each issue and the outcome.

How would you see the reports assisting you in the requirements specification process?

By doing a complete analysis of deficiencies.

Making a clear case for HF to get program manager "buy-in".

Are there remaining areas of uncertainty concerning the implementation of a HF program plan that are not addressed by the reports? YES.

What are they? What improvements could be made?

Would like to see a briefing package put together which summarises the main material, and that would make a clear case effectively to be used in a short briefing.

There could also be a separate document "Making the case for HF" to support any presentation package.

Would like to see checklists provided to guide the collection of data in usability trials.

The reports should make it clear that users of systems are not just operators but also maintenance personnel.

Need to describe a process for data traceability.

5.1: the system description should be extended to include what you would like the system to do in specific terms.

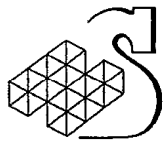
5.1.6: Testing should be *required,* not optional as implied here.

5.2.4: Section is difficult to follow

5.2.5: c, d, could be clearer: need also to identify those *repetitive* tasks which are candidates for automation.

Liked the sections on using prototypes and simulations for training purposes, although the section could be further developed (e.g. the early development of symbology in the emerging system could be immediately adapted for training purposes).

Liked the specification of the HF requirements up front in the program plan.



5.3.1: Approach is unrealistic. Some compromises must be made.

Would like to see the HF plan clearly state the contractual requirements in delivering a HEPP. Need a way to ensure that the contract manager briefs other members of the contractor team on the centrality of the HEPP. The contractor needs to be specific about the relationship between the HEPP and the overall systems engineering plan. The HEPP must be seen to have the same status as the software and hardware engineering plans and must be integrated with these processes. Must ensure that the contractor buys into this.

Instead of a general reference to Milspecs, program managers are expected to refer to the appropriate sections for call-up. The reports does not facilitate this selection process.

User Manual

Liked how to use manual and specifically sections 3.4, 4.2.6.7, 4.2.7, 4.3.1.2, 4.5, 5.2.2

4.2.6.5: this section on MOPs needs considerable strengthening.

4.3.5: definition of prototype is too constraining

5.3.2.6: Concerned about reference to schedule "delay" here: this is a red flag to system developers. The emphasis should be on the value added, not the potential for delay.

5.5: This needs to be supplemented and developed and condensed into a separate briefing package of 2-3 pages only.

Comments on experiences with HF analytical processes used on the R/SAOC project
HF Analyses

The initial task analysis produced lots of data, but this has not yet been exploited to its full potential. There was too much data to be useful. An independent assessment of the data would be useful to provide future guidance on how it could best be implemented into the program.

The workload analysis data describing workload peaks provided only a limited insight into the underlying deficiencies. The data did not address situation awareness or communication issues to the level required.

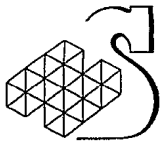
The list of tasks produced by the task analysis was widely used by the contractor.

The separate cognitive task analysis is still reaping additional benefits. The CTA generated a different type of data from the TA and was of benefit in different areas. The TA was seen to describe *what* tasks were done, whereas the CTA addressed *how* tasks were done and the information format required to support these tasks.

The requirements development process was able to use the output of the TA. This needed to be supplemented with material from the CTA, which provided information on detailed design issues concerning the flow of information, and the design of specific screens.

The TA and OSD decomposition helped to generate a checklist for function development, but the modelling data were not used systematically.

Issues need to be addressed concerning the competing priorities for time and resources that may result from two potentially competing aspects of the HF program. First, the generation and use of HF data to directly support the *development* of the specific program in question, second, the need for the HF program to also provide a more general HF benefit for *research* into broader military applications.



Annex B. Overview of the concept of situation awareness

The term situation (sometimes situational) awareness is frequently heard within the military, human factors and systems development communities. In many instances, military users of the phrase have adopted it to describe a state or process that is specific to their own operational circumstances. System developers may also use the term in a unique way to describe a particular technology, for example, a new, mobile tactical display that could be potentially deployed in military vehicles has been described as an "advanced situation awareness system." The widespread variation in the usage of the phrase is done without the realisation that there is a reasonable consensus among the HF community on the meaning of the term.

This consensus has been reached through a variety of quantitative and analytical studies over the last decade, and the interested reader is directed to reference 10, which provides a good overview of recent empirical and theoretical work in the field.

Some examples of the variation in the way situation awareness has been defined in the HF literature are:

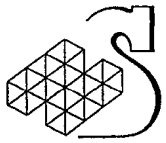
> *"the pilot's knowledge of his surroundings in the light of his current goals".*
>
> *"situation awareness is the accessibility of a comprehensive and coherent situation representation which is continuously being updated in accordance with the results of recurrent situation assessments"*
>
> *"situation awareness is up-to-the-minute comprehension of task relevant information that enables appropriate decision making under stress".*

Perhaps the most widely quoted, and possibly accepted, definition is provided by Endsley (reference 11): *"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future".*

In Endsley's conception, situation awareness is to be clearly differentiated from both decision making and action (or performance). Situation awareness serves as the cognitive *antecedent* to the decision making process by providing the appropriate information for decision input. Situation awareness is part of the individual's internal model of the environment. It follows, therefore, that if situation awareness is degraded, then sub-optimum decision making will likely occur. The corollary is not true however, having complete and perfect information as part of the operator's situation awareness is no guarantee that the appropriate or correct decision will be made.

Endsley has characterised three fundamental aspects of situation awareness, which she refers to as "levels" as follows.

Level 1: Perception of the elements of the environment
This involves the processes of search, detection, recognition and identification of the relevant status, features and attributes of the environment that are pertinent to the goals in hand. The usual assumption is that the information required to develop situation awareness is potentially obtained from multiple sources in the operating environment.



Level 2: Comprehension of the current situation
Comprehension is achieved through the integration and synthesis of the relevant, disparate information that is acquired through Level 1. In this process the individual goes beyond the detection of the information that is present in the situation and seeks to determine the significance and meaning of it. In some cases, this may produce a holistic picture, or internal representation, of the environment. In complex environments the ability to achieve this level of comprehension will be dependent upon the skill and knowledge that is acquired through experience.

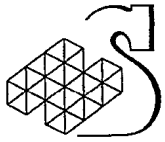
Level 3: Projection of future status
This refers to the requirement of an individual to anticipate or envisage the future status or actions of the elements in the environment over a near time frame. Endsley is not specific about the exact nature of the time frame. This may be contextually dependent and related to the rate of information that needs to be attended to, and the underlying time scale that is required to achieve goals. In an air combat context, the time frame may be in matters of seconds, in naval engagements, it could be minutes or hours.

These three levels really describe *processes* relevant to the establishment and maintenance of situation awareness, rather than *a state of mind*. However, for many users of the concept, situation awareness also means the internal state arising from the level 2 process. This internal state is frequently described in pictorial or graphical terms when military users talk about "losing the picture", "seeing the big picture" and "battlefield visualisation".

From the perspective of HFE analysis particularly in the context of CCIS, the concept of situation awareness may provide some useful perspectives that complement mission, function and workload analysis. Situation awareness and workload are intimately inter-related, since if a system fails to support the user's needs in acquiring and maintaining situation awareness of the operational environment, ensuing workload may be high. However, it has been argued that to some extent the two concepts are orthogonal. Thus, one can have high workload and low situation awareness in some circumstances. This could occur when an individual has no idea of what is going on and working very hard to find out, or if the volume of information is so great that attention is too narrowly focussed on a subset of information.

As an example, we could apply an analysis based upon Endsley's three levels to address the design requirements for a tactical map. An analysis of the operator's level 1 needs would identify the specific information that must be readily detected and comprehended. This in turn would have design implications for how the data may be displayed to enhance conspicuity and meaning. This would be augmented with an analysis based on level 2 requirements, which would identify information that must be readily integrated in terms of the local operational goals.

If design requirements addressed to level 2 needs are ignored, the resulting system may fail to support the user in the difficult task of integrating information, for example, between local and more global views of the battlefield. This in turn will cause an increase in workload from two sources. First, the user may take additional time (the primary driver of workload) to switch back and forth between map views, in order to build an integrated picture. Second, the user may be forced to perform mental transformations of the internal representation of the data in order to provide the appropriate battlefield picture. The analysis of requirements for information integration to form a coherent and comprehensible view of the operating environment is particularly important for system designs in which the user must interact with multiple displays and other information sources to acquire the necessary state of situation awareness.



An analysis that takes into account level 3 situation awareness requirements provides important information on how to design for environments in which the operator must project the current situation ahead in time. This projection can take a variety of forms, e.g. envisaging what the disposition of forces in the battlefield will look like at some tactically relevant future time, planning a route, or assigning mental priorities for a critical path for upcoming tasks in a multi-tasking environment.

A common approach to performing an analysis of situation awareness requirements is to start by identifying the specific goal that an operator is trying to accomplish at a given time. This is followed by determining the critical pieces of information that must be integrated into situation awareness for the goal to be successfully accomplished. Special attention is given to information that must be perceived and understood quickly and which information is of less salience to the operator. (Note – depending upon the goal at hand, information that is less salient for one goal, may be highly critical for another). The next step is to consider how the detected information is integrated by the user to provide comprehension. This may require that the format of disparate pieces of information be transformed in a particular way to facilitate their integration. For this purpose, it will be desirable to establish the timeframe over which the information will be used and the dynamics of any decision making resulting from the current awareness of the situation. For tasks involving planning, or anticipation of the way in which the operational context will change in the future, additional analysis will be required to determine which aspects of information have to be projected forward over time and how the operator will use such information.

In summary, an analysis of the operator's goals and associated states of situation awareness has the potential to provide a significant value-added component to the processes of requirements specification, and subsequently detailed system design. This is achieved by taking into consideration how the information provided by a CCIS must be matched to the particular way in which information will be used by the operator in a specific operational context. A successful analysis will therefore contribute to improving the probability that new system designs will contain the necessary flexibility and adaptability to meet a user's varying information needs contingent upon the current goals in hand.

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